

THE INVENTION CLAIMED IS:

1. A microelectronic sensor system comprising:
  - at least one separation channel,
  - at least one interferometer,
  - at least one modulated excitation beam having a wavelength,
  - at least one light source, and
  - at least one photo receiver.
2. The microelectronic sensor system of claim 1, including an integrated chip, wherein said separation channel and said interferometer orthogonally intersect each other at least once on said integrated chip.
3. The microelectronic sensor system of claim 1, including a single integrated chip, wherein said separation channel, said interferometer, said light source, and said photo receiver are on said single integrated chip, wherein said separation channel and said interferometer intersect each other orthogonally at least once.
4. The microelectronic sensor system of claim 1, wherein said separation channel is an electrophoresis capillary.

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5. The microelectronic sensor system of claim 1, wherein said separation channel is a gas chromatography column.
6. The microelectronic sensor system of claim 1, wherein said separation channel is a high performance liquid chromatography column.
7. The microelectronic sensor system of claim 1, wherein said separation channel is a size exclusion chromatography column.
8. The microelectronic sensor system of claim 4, wherein said capillary electrophoresis includes traveling wave dielectrophoresis.
9. The microelectronic sensor system of claim 1, wherein said modulated excitation beam is a laser beam generated from an excitation laser, wherein said laser beam is chopped by an optical chopper.
10. The microelectronic sensor system of claim 9, wherein said optical chopper chops said laser beam at approximately 1 kHz.
11. The microelectronic sensor system of claim 9, wherein said excitation laser is an argon ion laser.

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12. The microelectronic sensor system of claim 1, further comprising:

a lock-in amplifier.

13. The microelectronic sensor system of claim 12, further comprising:

a probe laser,

a polarization-maintaining fiber used to couple all components,

an integrated optical circuit having two phase modulators and a Mach-Zehnder interferometer.

14. The microelectronic sensor system of claim 13, wherein said probe laser is a

superluminescent diode supplying 1 mW continuous wave at a center wavelength of

1315 nm with a full-width, half-maximum of 46 nm, said Mach-Zehnder interferometer

has an optical path distance between about 585.5  $\mu\text{m}$  and about 589.5  $\mu\text{m}$ , one of said

phase modulators produces a phase shift of about  $200^\circ$  at a current of 100mA, and the

other of said phase modulators produces a phase shift of about 500 at a current of about

100 mA.

15. The microelectronic sensor system of claim 1, wherein said interferometer has an

optical path distance between about 566  $\mu\text{m}$  and about 606  $\mu\text{m}$ .

16. The microelectronic sensor system of claim 1, wherein the interferometer is

interrogated with a narrow line diode laser operating at 1310nm.

17. The microelectronic sensor system of claim 1, wherein the interferometer is interrogated using a phase generated carrier technique.
18. The microelectronic sensor system of claim 1, wherein the interferometer comprises a component of a white light interferometry system.
19. The microelectronic sensor system of claim 13, wherein the white light interferometry system is interrogated by a phase generated carrier technique.
20. The microelectronic sensor system of claim 2, wherein said modulated excitation beam passes through said separation channel at a position normal to the surface of said chip at a point where said separation channel and said interferometer orthogonally intersect.
21. The microelectronic sensor system of claim 20, further comprising:
  - a plurality of sample processing equipment,
  - a power supply, and
  - a central processing unit.
22. The microelectronic sensor system of claim 21, wherein said sample processing equipment comprises:

an first end port,  
at least one micro pump,  
at least one micro valve,  
an exit port, and  
at least one reagent cartridge.

23. The microelectronic sensor system of claim 22, further comprising a second end port.

24. The microelectronic sensor system of claim 20, wherein the wavelength of said modulated excitation beam is selected to match an analyte absorption spectra.

25. The microelectronic sensor system of claim 1, said interferometer having a sample arm and a reference arm, said separation channel having a first end port, a second end port and an exit port located approximately in the center of the separation channel, wherein said sample arm orthogonally intersects said separation channel at a sample position located between said first end port and said exit port and said reference arm orthogonally intersects said separation channel at a reference position located between said second end port and said exit port.

26. The microelectronic sensor system of claim 25, further comprising:

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a beamsplitter, wherein said beamsplitter divides light from said modulated excitation beam into at least two approximately equal beams, producing a first excitation beam and a second excitation beam, wherein said first excitation beam passes through said separation channel at said sample position and said second excitation beam passes through said separation channel at said reference position.

27. A sensor system, comprising:

a modulated laser excitation source,  
a separation capillary,  
ports in said separation capillary,  
electrodes in said ports,  
an interferometer having  
a first arm directed into said separation capillary and  
a second arm directed into said separation capillary, and  
an optical instrument that measures the interferometric state of said  
interferometer.

28. An integrated sensor system device, comprising:

a separation capillary embedded inside of a solid material substrate such as  
glass,  
a laser excitation source,  
a chopping device to modulate said excitation source,

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a beam splitter that divides light from said chopped excitation source into at least two approximately equal beams,

a buffer solution,

an analyte dissolved in said buffer solution,

a multiplicity of end ports into said capillary being respectively located at the two ends of and in the approximate center along the length of said capillary, with said analyte dissolved in a buffer solution being introduced into said capillary through the first of said end ports, and said buffer solution without analyte being introduced into said capillary through the second of said end ports and all of said fluids exiting through said center port,

three electrodes deposited upon said substrate and immersed in said fluids in said ports,

high-voltage direct-current power supplies interconnected between said electrodes,

an interferometer formed from optical waveguides embedded inside of said solid material substrate, said interferometer having a first arm and a second arm, with said first arm operatively intersecting said separation capillary and said first beam of laser excitation source at a location between said first end port and said center port, and said second arm operatively intersecting said separation capillary and said second beam of laser excitation source at a location between said second end port and said center port, and

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an optical instrument that measures the interferometric state of said interferometer.

29. A sensor system, comprising:

a separation capillary,  
a laser excitation source,  
a chopping device to modulate said excitation source,  
a beam splitter that divides light from said chopped excitation source into two approximately equal beams,  
a buffer solution,  
an analyte dissolved in said buffer solution,  
three ports into said capillary being respectively located at the two ends of and in the approximate center along the length of said capillary, with said analyte dissolved in a buffer solution being introduced into said capillary through the first of said end ports, and said buffer solution without analyte being introduced into said capillary through the second of said end ports, and all of said fluids exiting through said center port,  
three electrodes immersed in said fluids in said ports,  
several high-voltage direct-current power supplies interconnected between said electrodes,  
an interferometer, said interferometer having a first arm and a second arm, with said first arm operatively intersecting said separation capillary and said first beam of laser excitation source at a location between said first end port and said center port, and

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said second arm operatively intersecting said separation capillary and said second beam of laser excitation source at a location between said second end port and said center port, and

an optical instrument that measures the interferometric state of said interferometer.

30. A micro-analytical method of analyzing an analyte, comprising the steps of:

delivering a modulated excitation beam to a separation channel having a first end port and an exit port,

introducing an analyte into the first end port of said separation channel such that the analyte travels in the direction from said first end port to said exit port,

measuring the change in the index of refraction of light versus time at a sample position located between said first end port and said exit port in the separation channel using an interferometer.

31. The micro-analytical method of claim 30, further comprising the steps of:

dissolving said analyte in a reference material before introduction into said separation channel,

introducing a reference material into a second end port of said separation channel, such that the reference material travels in the direction from said second end port to said exit port creating a time-varying index of refraction along said separation channel,

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measuring the change in the index of refraction of light versus time at a reference position between said second end port and said exit port in the separation channel using an interferometer.

32. The micro-analytical method of claim 30, further comprising the steps of:

vaporizing said analyte in a carrier gas before introduction into said separation channel,

introducing said carrier gas into a second end port of said separation channel, such that the carrier gas travels in the direction from said second end port to said exit port creating a time-varying index of refraction along said separation channel,

measuring the change in the index of refraction of light versus time at a reference position between said second end port and said exit port in the separation channel using an interferometer.

33. A method of analyzing an analyte, comprising the steps of:

delivering a modulated excitation beam to a separation channel having a first end, a second end port and an exist port approximately in the center of said separation channel, wherein said excitation beam is split into two approximately equal optical excitation beams, wherein one of said optical excitation beams intersects the separation channel at a sample position located between said first end port and said exit port and the other optical excitation beam intersects the separation channel at a reference position located between said second end port and said exit port,

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introducing an analyte in a reference material into said first end port of the separation channel, such that the analyte travels in the direction from said first end port to said exit port,

introducing pure reference material into said second end port of the separation channel, such that the reference material travels in the direction from said second end port to said exit port,

measuring the change in the index of refraction of light versus time at a sample position between said first end port and said exit port in the separation channel and the change in the index of refraction of light versus time at a reference position between said second end port and said exit port in the separation channel using an interferometer with a first interferometer arm orthogonally intersecting the separation channel at said sample position and a second interferometer arm orthogonally intersecting the separation channel at said reference position,

demodulating said time-varying index of refraction with a lock-in amplifier synchronized to said optical excitation beams, and

recording the time history of said demodulated index of refraction.

34. The method of claim 33, further comprising the step of:

measuring the transit time of said analyte through said separation channel by observing the time of arrival of said time history data thus providing a temporal signature for the analyte.

35. The method of claim 34, wherein said separation channel is an electrophoresis capillary, further comprising the step of:

applying high voltage to said separation channel thus causing said analyte and reference material to flow toward and out of the exit port by electro-osmotic flow and with electrophoretic separation occurring.

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